Forest Inventory Audit Report - TFL 14 Crestbrook Forest Industries

August 1994

Introduction

Background

In British Columbia, forest inventories for specific areas are conducted usually every 10 to 30 years, with regular updates between re- inventories to reflect changes in the forest due to growth and depletions.

The question "How good is the current inventory?" often arises. A statistical auditing methodology has been developed to answer this question for specific management units in the provincial inventory. A cluster of ground sample plots are established in randomly selected forest stands or polygons (audit sample). The estimate of the average timber volume for these sample polygons from the ground plots (audit volume) is compared to the average timber volume for the same polygons estimated from the current inventory (inventory volume). This analysis determines the accuracy of the forest classification and the yield model projection components of the inventory system. In addition, by comparing yield estimates derived from the ground attribute information (ground attribute volume) versus the photo interpreted attributes, the accuracy of the yield prediction system and classification can be independently assessed. This technique allows the level of accuracy to be stated for the photo based attribute information and the yield model prediction components of the inventory.

Statistical analysis is used to assess the accuracy of the inventory and to assist in making decisions regarding re-inventory priorities.

The Forest Inventory Program refers to this statistical auditing methodology as an Inventory Audit.

This report presents the results of an inventory audit performed within Tree Farm License (TFL) 14, Crestbook Forest Industries. TFL 14 covers an area of 139,443 hectares in the Nelson Timber Supply Area (TSA). The geographic centre of TFL 14 is located approximately 32 km southwest of Golden.

The current inventory for TFL 14 was carried out between 1983 and 1986. The inventory has been periodically updated to reflect depletion's due to logging and reforestation activities.

In the case of TFL 14 and many other TFLs within the province, polygon specific inventory volumes are not available. In the case of TFL 14, volumes for the management unit inventory were assigned using equations that represent the average volume for aggregated species and site classes displaying similar silvicultural and management opportunities for the local area. These individual equations are called analysis units and are used in the timber supply process to assign volumes to the entire management unit. As the analysis unit volumes represent a varied number of inventory types and sites, it would be inappropriate to directly compare analysis unit volumes with ground based polygon specific volumes. Therefore, for the purpose of assigning polygon specific audit volumes, the Ministry of Forests, Variable Density Yield Prediction (VDYP) computer system was used.

The inventory audit was conducted in order to determine the overall accuracy of the current inventory in this TFL, given current standards and procedures. These audit results are unique to TFL 14 and cannot be applied to other areas in the province.

Methods

Current inventory

One of the most significant forms of tenure within British Columbia is the Tree Farm License. The area of

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a TFL can vary in size from 8,500 hectares to just over one million hectares each. Inventories are performed on the entire TFL. The current inventory methodology varies within each TFL, however, all the standards and procedures must be approved by the Ministry of Forests. New standards under development shall ensure a consistent minimum level of inventory standard for all TFLs. Generally, inventories are conducted by first delineating forest stands (polygons) on 1:15,000 or 10,000 scale photographs. A number of photo-interpreted variables are collected for each polygon including: species composition, stand height, age, and crown dimension. Volume is then estimated indirectly using these photo-interpreted variables and empirical yield equations. Other approaches to volume estimation, approved by the Ministry of Forests, may also be used.

To keep the estimates current between successive inventories, inventories are regularly updated for the effects of forest growth and depletions due to harvesting, fire losses, and the impact of insects and disease. Growth models or empirical yield equations, such as the Ministry of Forests' VDYP computer model, are used to update the inventory for forest growth. Field visitation, satellite imagery and aerial photographs may be used to update the inventory for depletions.

The inventory audit for TFL 14 is based on a sample of 49 polygons. The establishment of the audit sample is described below. For each of the 49 polygons, the existing photo-interpreted inventory variables, were projected to 1993 and input into VDYP to obtain 1993 estimates of the volume per hectare. For the inventory audit, these updated, photo-based, volume estimates were compared to the audit volumes (i.e. the ground volumes estimated from the audit sample).

Audit sample

The TFL 14 forest inventory maps produced in the inventory that was carried out between 1983 and 1986, were the basis for sampling. A random sample of 49 forested polygons, greater than 60 years of age from both the operable and inoperable portions of the TFL were selected for the inventory audit.

The sample was restricted to polygons greater than 10 hectares in area, therefore the results of the audit should be interpreted in that context.

Up to three full-measure prism plots, and nine count plots, were established within each of the 49 sample polygons. The plots were located systematically, using a triangular design and a randomly selected point as the starting point. For a large or irregular polygon, only a randomly selected portion of the polygon was sampled. In total, 147 full measure and 441 count plots were established. Field data collection followed the standard Ministry of Forests cruising procedures.

A mismatch of tree species within the count and full-measure plots may have introduced bias in terms of the percentage species composition, however, this would have minimal impact on the total volume estimates.

The field data were compiled following the standard ministry cruise compilation procedures. The goal was to obtain audit volumes that were comparable (in terms of utilization limits and merchantability definitions) to the inventory volumes that are produced from the VDYP system.

The VDYP system produces net merchantable volume per hectare defined as whole stem volume inside bark of all live trees to a 10 cm. diameter inside-bark top and a 30 cm. high stump, excluding decay as estimated from ministry loss factors. Dead potential and veteran trees are not included in the VDYP system volume estimates. This volume is output for two utilization standards: all live trees of 12.5cm+ dbh, and 17.5cm+ dbh.

The cruise compilation routine used for the audit sample in TFL 14 produced merchantable volumes that matched VDYP estimates in terms of utilization and loss factor reductions.

Once the audit volumes were obtained, they were compared to the inventory volumes to test the validity of the current inventory using current standards and procedures.

Results

Results of the statistical analysis of the inventory audit for volumes at a 12.5cm+ dbh utilization limit are given in Table 1.

Table 1. Statistics for the audit volume, VDYP inventory volume and VDYP ground attribute estimates at 12.5cm+ dbh utilization for TFL 14.

	Audit Volume (M³/ha)	VDYP Inventory Volume (M³/ha)	VDYP Ground Attribute Volume (M³/ha)
Mean	299	237	263
Coefficient of variation	36%	39%	35%
Standard error (SEE)	15.50	13.3	13.
Sampling error @ 95%	10.2%	11.0%	9.8%
95% Confidence Interval	268-329	211-263	237-289

Ratio of means: Audit Vol/Inventory Vol 1.26

The audit volume sampling error was 10.2%, (i.e. the confidence interval at the 95% level of probability) for the average audit volume of 299 +- 30 cubic meters per hectare. The corresponding average inventory volume (237 m^3) had a sampling error of 11% and a confidence interval of ± 26 cubic meters per hectare. The ratio of means estimate for the inventory audit of the average volume per hectare in TFL 14 was 1.26.

A two sided paired sample t-test showed that the average audit volume per hectare was significantly higher than the average inventory volume per hectare (at the 95% probability level). This same result was found for both the 12.5cm+ and 17.5c+ dbh utilization levels.

These results, predicted by VDYP, indicate the average inventory volume was underestimated by 62 m^3/ha. This difference can be attributable to error associated with either the forest attribute classification or the yield model prediction system used in this analysis.

Additional analyses were performed in order to further identify the specific sources of error in the inventory. The method used was to project the ground based label attributes through the VDYP system to estimate volume. This value was called the ground attribute volume. A large part of the difference between the ground attribute volume and the audit volume is probably an expression of the error associated with the VDYP system. A large part of the difference between the inventory volume and the ground attribute volume would be an expression of the forest attribute error.

The ground based attributes were derived by using stock table estimates of species composition, ground based polygon averages of top height and age, with crown closure taken from the original map label. The ground attribute volume sampling error was 9.8% (i.e. the confidence interval at the 95% level of probability) for the average volume of 263 ± 26 m^3/ha. This estimate was not significantly different (i.e. at the 95% probability level) from the audit volume.

The total difference between the average audit volume and the average VDYP inventory volume was 62 m^3/ha (total error associated with the forest classification and yield prediction system); with the difference between the average audit volume and the average VDYP ground attribute volume at 36 m^3/ha (error associated with yield prediction system). The difference between the average VDYP inventory volume and the ground attribute volume is 26 m^3/ha. (error associated with the forest attribute classification)

A standard Inventory Branch quality control check on the accuracy of the classification attributes indicated that on the average, the classification was 66% correct. The minimum required by the ministry is 85% correct. The standards are intended to compare similar photo based estimates. The results reported compare a photobased estimate versus a ground based estimate. The results should be viewed with caution.

Discussion and conclusions

Analysis of the data from the inventory audit of TFL 14 indicate that the inventory volume, as predicted in the previous discussion, is underestimated when compared to the audit volume.

The difference may be explained by:

1) error associated with the forest classification attributes (eg. inventory variables such as height, age, species composition and crown closure); and,
2) error associated with the volume prediction system (VDYP).

The data indicate that of the total 62 m^3/ha underestimation in volume, 36 m^3/ha is probably attributable to error with the VDYP prediction system and application, while a further 26 m^3/ha is probably attributable to error in classification.

The error associated with the VDYP system and application may be caused by many factors. The system is based on empirical data collected from broad geographic regions throughout British Columbia that do not represent specific land management units. Specific growth rates, loss factors and tree volume equations have not been localized within the VDYP system. These issues are areas of on-going development within the Ministry of Forests Inventory Branch. The inability of the VDYP system to predict volumes with varying decay reductions does not allow further examination of the system deficiencies.

The existing TFL 14 inventory is based on class based attribute values. The VDYP system and current inventory standards assign continuous variable attributes. Specifically, the highly volume sensitive, height variable used in this analysis is a class-based mid-pointed attribute value. The difference between the average ground-based top height estimate and the average dominant / co-dominant label height estimate is an underestimation in label height of 1.6 m. Although the difference in height was not significantly different at the 95% probability level, this apparently minor difference would have accounted for a significant proportion of the error in volume. The level of error associated with the different height sampling methodologies is unknown.

The results of this audit identify several possible areas of discrepancy within the existing inventory in TFL 14, and within the Ministry of Forests VDYP system. Under the guidance of the Ministry of Forests the licensee will update the inventory of the TFL to today's standards.

Glossary

Bias: A systematic error introduced into sampling or testing by selecting or encouraging one outcome or answer over others.

Coefficient of variation: The ratio between the standard deviation and the mean value. (i.e. an expression of the variation of a data set)

Confidence interval: A range within which we expect the "true" value to be.

Dead useless: Dead standing or down trees that have less than 50 per cent of their original gross volume in firm wood content.

Mean: The average value of a set of observations.

Polygon: A delineated area with a homogenous forest.

Ratio estimate: The ratio between two different estimates, which can be used to adjust the estimate with the lower accuracy.

Sample: To collect information of a portion of the population in a way that it can be expanded to whole population.

Sampling error: The variation around a sample mean which decreases with increasing sample size.

Significant difference: An expression used in reference to the results of a statistical test in which estimates obtained by one method are compared to what is expected. If a specified test criteria occur indicating a difference, the difference is described as being significant.

Standard deviation: A measure of how well a sample has estimated the "true" value.

Standard error: An expression of the variability of an estimate.

Taper equations: Equations which recreate the shape of trees in a computer, and are used to estimate tree volume.

Timber supply area: An integrated resource management unit established in accordance with section 6 of the *Forest Act*.

Tree farm license: An integrated resource management unit established in accordance with section 28 of the *Forest Act*.

For more information

For more information or to obtain other inventory audit reports, contact:

Forest Inventory Branch,
722 Johnson Street,
Victoria, B.C.
V8W 3E7
387-1314 or fax 387-5999

Notes

Province of
British Columbia
Ministry
of Forests